Exhibit I

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WCDMA UMTS Deployment Handbook

Planning and Optimization Aspects

WILEY

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Foreword

Mobile wireless communications has already dramatically affected our lives, and will continue to do so as usage, services, and coverage rapidly expand with the adoption of the Third Generation of cellular wireless, and the transition to Internet-protocol-based networks.

First Generation cellular networks used analog FM and circuit switching. Despite low voice capacity, uneven quality, limited roaming, and bulky, expensive handsets with limited battery life, the rapid increase of voice subscribers necessitated the adoption of digital transmission technology.

Second Generation (2G) networks, including TDMA-based GSM, PDC, IS-54, and CDMA-based IS-95, allowed rapid expansion of voice subscribers and the introduction of some data services, including short message service (SMS). These Second Generation digital technologies featured advanced coding and modulation, offering greater voice capacity and quality, and supporting digital control channels. The result? More robust and secure signals, smaller and lower-power handsets, enhanced roaming, and a rapid expansion of subscribers worldwide. Even with the limited data capabilities of 2G technology, it became clear that a next generation of cellular networks should focus on even greater capacity, high speed data, and increased reliance on packet switching.

Third Generation (3G) wireless, encompassing three forms of CDMA–CDMA2000®, including 1X and EV-DO; WCDMA, also called UMTS and 3GSM; and most recently TD-SCDMA–has been introduced by many operators and is rapidly gaining subscribers. Both plug-in cards and integral modems are supporting broadband mobile communications directly to laptops. An abundance of powerful handsets are now reaching the market, which support a wide variety of services including music, streamed and stored video, multiplayer games, multiparty instant messaging, and location-based services.

Such growth in usage and applications poses great challenges for the network operators, test equipment vendors, infrastructure manufacturers, and the technical staff that plan, deploy, and operate these networks. This book focuses on the knowledge needed to effectively deploy Wideband CDMA (WCDMA) networks, much of which has been either publicly unavailable or widely scattered across various journals and other sources. In gathering and distilling this knowledge in a readable and coherent form, the authors have achieved their goal of further speeding the deployment and optimization of WCDMA networks.

Third Generation cellular networks will enhance our lives in many ways, rapidly reaching every part of the world and supporting education, business, entertainment, health, and government. The demand for knowledgeable practitioners will continue to grow. This book should provide welcome assistance.

We have come a long way. I look forward to the excitement of further rapid change.

Irwin Mark Jacobs
Chairman of the Board
QUALCOMM Incorporated

Preface

In our day-to-day activities, as part of the Engineering Services Group of QUALCOMM®, we consult with network operators throughout the world. In working with them, we have realized that operators repeatedly face the same four challenges: improving RF optimization, properly tuning system parameters, increasing the reliability of inter-system transitions, and providing better indoor coverage. These issues, among others, cannot be resolved simply by studying the communication standard; consequently, they have not been widely addressed in the literature.

In this book, using the experience we have gained from performing many network assessments, we focus on the day-to-day tasks and real world choices that confront operators. We have chosen to minimize paraphrasing of the standard. This is not to say that we disregard the ample documentation written by the Third Generation Partnership Project (3GPP), also known as the standard. We do refer to the standard throughout this book but rather than present its concepts in a dry manner, we introduce only the sections that readers can use to deepen their knowledge on specific topics. We selected these topics to help network planners and optimization engineers make a better transition from GSM to WCDMA while understanding how to perform the required tasks.

This volume attempts to provide as many answers as possible to the complex questions that planners or engineers encounter in their daily activities. As we were writing, we had to make difficult choices about what to include. Without these choices, of course, we would still be writing. Here are the basic questions that we tried to answer in each chapter:

- **Introduction to UMTS networks.** What nodes are necessary in a WCDMA network? What are their basic functions? What is WCDMA anyway? What differentiates WCDMA from other technologies, such as GSM? What are the key terms and concepts of the technology?
- **RF planning and optimization.** What is a typical Link Budget for the different services offered in WCDMA? Is the Downlink or the Uplink limiting? What are the main factors that determine the coverage? How can the coverage of a WCDMA network be qualified?
- **Capacity planning and optimization.** What is the capacity of a WCDMA cell? How does soft handover affect the capacity of a WCDMA network? How do the different services affect the overall capacity? How can the capacity of the network be maximized? Will microcells affect the capacity of the network?
- **Initial parameter settings.** What are the most important parameters to focus on? What is a good starting point for each parameter? How can you verify the values that are broadcast, and where?
- **Service optimization.** How should the optimization process be started? What are the basic procedures that will affect all services? What should you look for to resolve

typical failures? What differs from one service to another? Do any parameters apply only to particular services?

- **Inter-system planning and optimization.** Why rely on other systems? When should you start looking at inter-system issues? What parameters are involved in inter-system changes? What are good starting points for their respective settings?
- **HSDPA.** What is HSDPA? What advantages does it offer compared to a WCDMA (Release 99) network? How does it differ? How and where should HSDPA be deployed? What parameters are available in HSDPA? How do these parameters affect the coverage and capacity of the entire network?
- **Indoor coverage.** Why is indoor coverage different? When should indoor coverage be provided? How can it be achieved and optimized?

By the time you have read this book, you will no doubt be ready to ask several more questions. Hopefully, with the aid of this book, you will have the skills to find the answers you need.

4

Initial Parameter Settings

Christopher Brunner, Andrea Garavaglia and Christophe Chevallier

4.1 Introduction

Network parameters play an important role in determining the correct behavior of the system and in achieving target performance. This chapter focuses on the initial settings for system parameters, to guarantee reasonably good operation of the network at the beginning of the optimization process or upon the friendly launch of services. For further insight into optimizing and fine-tuning the parameters, see Chapter 5.

As in many telecommunication systems, the parameters are intended to give the operator enough flexibility to (re)configure the network according to a specific strategy and development stage, without having to modify the corresponding network element software. In UMTS systems, the system parameters are typically stored in the RNC and Core Network (CN) databases and can be managed via the Operation and Maintenance Center (OMC). The parameters are then distributed with appropriate signaling to the network elements, as well as to the UE (user equipment).

Most of the signaling that involves system parameters is done through Layer 3 signaling. From a UTRAN point of view, the Radio Resource Control (RRC) protocol [1] plays a major role. The RRC has a control interface for each of the layers and sub-layers belonging to the Access Stratum (AS) with the capability to start, stop, and configure all of them. Other protocols used to set AS parameters are the Medium Access Control (MAC) protocol [2], the Radio Link Control (RLC) protocol [3], the Packet Data Convergence Protocol (PDCP) [4], and the Broadcast/Multi-cast Control (BMC) protocol [5]. Non-Access Stratum (NAS) parameters are usually defined in the CN [6] and distributed to the different network elements of the UTRAN by the RNC over the Iu [7], Iur [8], and Iub [9] interfaces using the corresponding protocols.

4.1.1 Broadcast of System Information

The RRC is the overall controller of the AS of UMTS, responsible for configuring all the involved layers and providing the signaling interface to the NAS layer. The RRC is also

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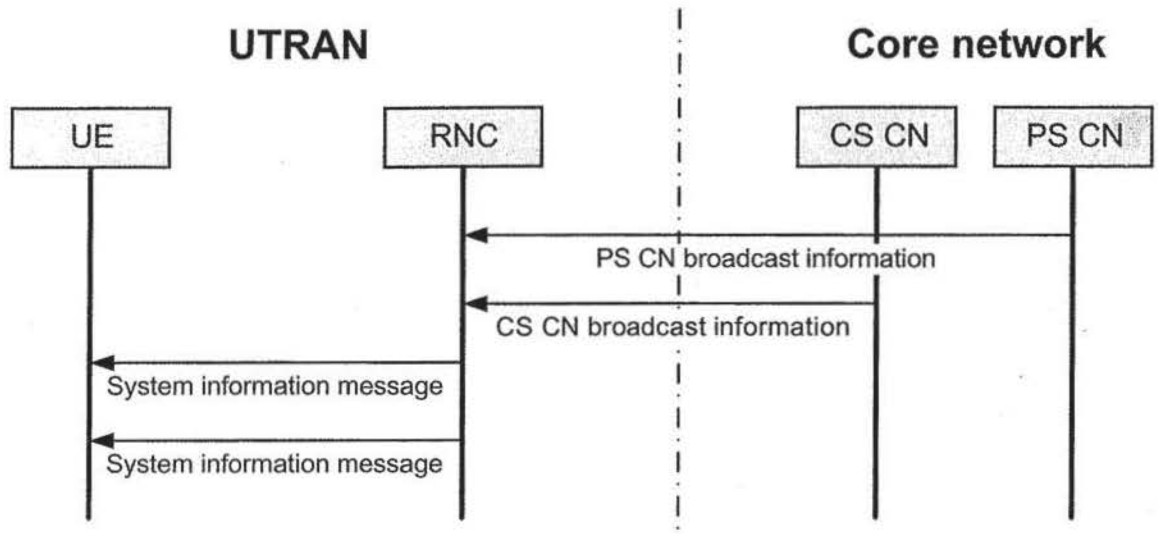

Figure 4.1 System information processing in UMTS

responsible for a set of procedures that establish, route, retain, and release the connection between the UTRAN and the UE.

One of the key RRC procedures for setting parameters is the *Broadcast of System Information*. This broadcast transfers the corresponding system parameters to all the UE present in a cell. As shown in Figure 4.1, system information includes Information Elements (IEs) from both the AS (originated from the UTRAN) and the NAS (originated from the CN). Both kinds of information are collected by the RNC and distributed to the UE as System Information messages, using the RRC protocol. The messages are sent on a logical Broadcast Control Channel (BCCH), which is mapped to either the BCH or the FACH Transport Channel.

The system information elements are broadcast in System Information Blocks (SIBs). A SIB groups together system information elements of the same nature. Different SIBs may have different characteristics in terms of scope (PLMN or cell), repetition rate, and requirements on the UE to read the SIB. Fast-changing (dynamic) parameters and more static parameters are grouped into different SIBs to prevent frequent reading of the same information.

To accommodate SIBs of very different sizes, a System Information message can carry either several complete SIBs or only a part of a SIB, while always fitting into the BCH or FACH transport blocks. A total of 11 combinations are allowed, according to the standard [10], with SIBs that can either be aggregated together in the same message or segmented into several messages, depending on their size.

Figure 4.2 shows the organization of the SIBs. A single Master Information Block (MIB) contains the scheduling information for the SIBs. One or two additional Scheduling Blocks may optionally be included in the MIB to provide schedule information for the rest of the SIBs. Some IEs are duplicated in different SIBs, for example Cell Reselection parameters in SIB3 and SIB4 (also grouped in Figure 4.2). SIB3 is used when the UE operates in Idle Mode, while SIB4, if transmitted, is used in Connected Mode. In this example, the transmission of SIB4 is signaled by a flag in SIB3, indicating that the UE needs to read additional information from (in this case) SIB4. To avoid any conflict or

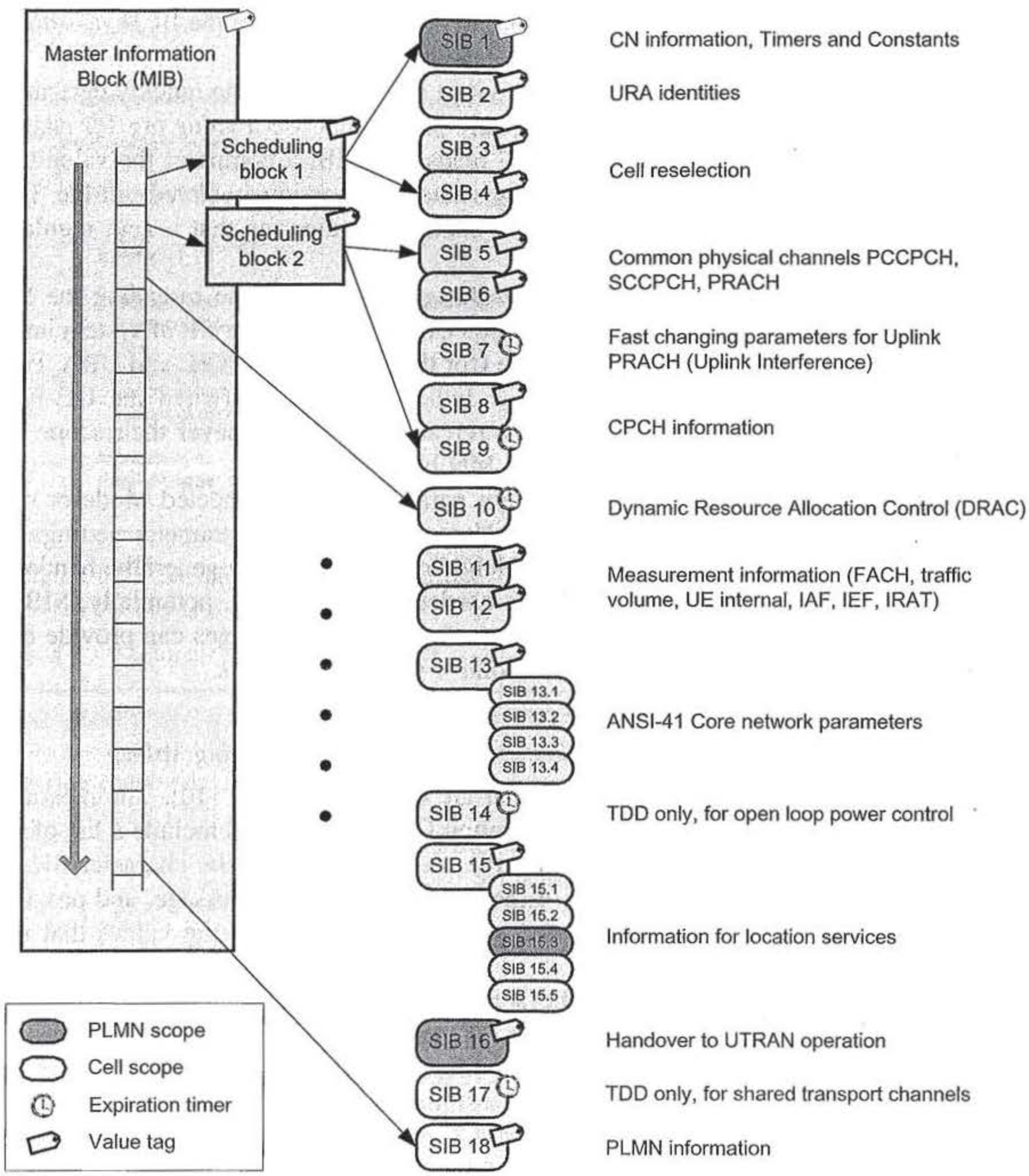

Figure 4.2 Structure of system information blocks according to 3GPP standard [10]

undefined behavior, the standard also defines the default values when specific SIBs are missing. In the previous example, if SIB4 is not transmitted, the UE defaults to SIB3.

It can be noted in Figure 4.2 that the legend (bottom left) provides the scope and the change control method for the different SIBs.

When a UE first camps on a cell, it must read all of the broadcast SIBs for that cell according to the schedule in the MIB, thus retrieving the parameter values. Because of this process, the SIB scheduling affects the reselection performance, since the reselection can only be effective after all the SIBs have been read. To mitigate this effect, the UE may optionally store System Information messages for a given cell so that they can be used

later when returning to that cell, without having to read them all from the BCH–assuming none of the parameters has changed since the UE last read the SIBs.

Each SIB has a defined method of change control to allow the UE to quickly determine if the content has changed. SIBs with more static parameters use a *value tag* for change control, distributed by the MIB. When the UE reads the MIB, it compares the value tags for the scheduled SIBs with the corresponding value tags previously stored; all the SIBs with new value tags are reread. The MIB also contains a value tag that is sent regularly by the UTRAN on a static schedule.

More dynamic SIBs use *SIB-specific timers* for change control, so rereading the SIB can be triggered by timer expiration. The UTRAN can also inform the UE of system information changes with a Paging Type 1 message (for the Idle, CELL_PCH, and URA_PCH states) or with a System Information Change Indication message (when the UE is in the CELL_FACH state). Finally, the UE must reread the SIBs whenever their scope has changed, because of moving across cell or PLMN boundaries.

SIBs are not the only way to modify system parameters. In Connected Mode or during the RRC connection process, the UTRAN may change the parameter settings by means of RRC messages. An example is the Neighbor List and, more generally, handover parameters. In Idle Mode this information is carried by SIB11 and, potentially, SIB12. Once the connection is established, the Measurement Control Messages can provide new information to the UE, for a more dynamic control of the parameters.

4.1.2 Translation between Information Element Values and Engineering Values

The RRC protocol uses a set of messages that are described in Ref [10]. The messages are encoded by means of Abstract Syntax Notation One (ASN.1) and include a list of IEs with the corresponding values. For each IE, the standard specifies the characteristics in terms of validity range and the presence of the element in a given message, and provides a one-to-one mapping between the encoded values and the engineering values that will be applied to the system.

To analyze performance and verify the actual settings, it is important to extract the correct engineering values for the parameters of interest from the encoded messages, as illustrated in the following example. Consider a Measurement Control Message sent by the RNC to request the UE for intra-frequency measurement reports for Event 1a (a primary CPICH enters the reporting range). In Figure 4.3, part of the original encoded message is reported on the left, and the parameters of interest for the example are highlighted in bold.

By applying the mapping as specified by the standard (see Table 4.1), it is possible to extract the real engineering values of the parameters from the message, as indicated in the right side in Figure 4.3. Some tools that are used to analyze and set parameters may be able to convert directly from IE to engineering values, on the user interface.

4.1.3 Over-the-Air Parameter Verification

After completing the initial parameter settings, it is a good practice to verify if what is transmitted over-the-air corresponds to the desired values set in the databases. At first glance, this seems superfluous; however, practical experience shows that there are always cases where the real parameters transmitted by the network elements differ from